ETSI WG TM6
(ACCESS TRANSMISSION SYSTEMS ON METALLIC CABLES)
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Living List for Spectral Management SpM - part 1 revision of TR 101 830-1

This document is the living list of current issues connected with ETSI's spectral management report TR 101 830, part 1 (*Definitions and signal library*).
This work item is focussed on the revision of "Part 1", to add new signal descriptions suitable for VDSL2 in the subloop (with PSD shaping). A target date for "working group approval" is scheduled for ***Dec 2007***. The issues related to revising "Part 2" are beyond the scope of this living list.

Why adding *dedicated* VDSL2 signals? The VDSL2 signal descriptions in G993.2, combined with shaping mechanisms in G997.1, enable an infinite number of PSD masks (different bandplans, many profiles, parametric definition of PSD shaping, presence of notching, etc). This facilitates very flexible VDSL2 products, but is far too complex to be helpful for defining what signal limits are allowed in cables within various countries. It would require an advanced simulation tool to find out what the actual limits are.
The SpM-1 document can fill-in this gap by offering a library with a finite number of dedicated VDSL2 signal descriptions that are tailored to specific applications; at least those that are made available for usage within a European country. Since all of SpM-1 is *informative* in nature, ETSI does not impose anybody to make use of one of these descriptions. Using it is purely an issue of *national concern* and *national regulation.* However, many European players have an interest that such signal descriptions are technically correct and unambiguous.

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2. STUDY POINTS PART 1(LIBRARY OF SIGNALS)

SP	Title	Owner	Status
1-1	Descriptions for “VDSL2-NL1” signals (“over POTS”)	Rob van den Brink (KPN/TNO)	Agreed
1-2	Descriptions for “VDSL2-NL2” signals (“over ISDN”)	Rob van den Brink (KPN/TNO)	Prov agreed
1-3	Descriptions for “VDSL2-UK1” signals	John MacDonald (BT)	US
1-4			
1-5			
1-6			
1-7			
1-8			

The current agreed procedure for changing the status of living list items is in Annex A of TM6 working methods.

Part 1 study points

SP 1-1. Description for “VDSL2-NL1” signals (“over POTS”)
This study point is dedicated to a technically correct description of the VDSL2 signals being allowed in the Netherlands, which may share the line with POTS signals. (See also *www.kpn-wholesale.com*, at “*documents|national|local loop services|reference offer SLU*”)

- *063t07r1, sept 2006, Description of “VDSL2-NL1” signals, for spectral management in the Netherlands – KPN/TNO*

SP 1-2. Description for “VDSL2-NL2” signals (“over ISDN”)
This study point is dedicated to a technically correct description of the VDSL2 signals being allowed in the Netherlands, which may share the line with ISDN signals. (See also *www.kpn-wholesale.com*, at “*documents|national|local loop services|reference offer SLU*”)

- *064t25, nov 2006, Description of “VDSL2-NL2” signals, for spectral management in the Netherlands – KPN/TNO*

SP 1-3. Description for “VDSL2-UK1” signals
This study point is dedicated to a technically correct description of the VDSL2 signals being allowed in the United Kingdom, compliant with the UK Access Network Frequency Paln (ANFPi3).

- *072t12, feb 2007, Description of “VDSL2-UK1” signals for spectral management in the United Kingdom – BT*

Text proposals, for inclusion in the revised SpM-1.

Remove all references to the existence of “part 3”, since that project has been withdrawn by ETSI-TM6

1. REFERENCES

[1] ITU-T Recommendation G993.2: “Very High Speed Digital Subscriber Line 2 (VDSL2)”, Pre-published, Geneva, February 2006

[2] ETSI TS 101 270-1 (V1.4.1): "Transmission and Multiplexing (TM); Access transmission systems on metallic access cables; Very high speed Digital Subscriber Line (VDSL); Part 1: Functional requirements".

[3] ITU-T Recommendation G.992.1: "Asymmetric digital subscriber line (ADSL) transceivers".

[4] ETSI TS 101 388 (V1.3.1): "Transmission and Multiplexing (TM); Access transmission systems on metallic access cables; Asymmetric Digital Subscriber Line (ADSL) - European specific requirements [ITU-T Recommendation G.992.1 modified]".

2. SIGNAL DESCRIPTIONS

2.1. "VDSL2-NL1" signals (“over POTS”)

This category covers signals up to 12 MHz, generated by VDSL2 transmission equipment using band plan 998 (limit PSD mask B8-4). These signals may share the same wire pair with POTS signals.
This signal description is derived from the ITU VDSL2 recommendation [1], and enhanced by loop dependent PSD shaping, also known as downstream Power Backoff. The signal limits are therefore dependent on the *attenuation distance* between the local exchange and cabinet (“primary cable”), defined as the insertion loss (IL) of that loop measured at 300 kHz into a resistive load of 100 Ω. The limits in this description are specified for a discrete number of (integer) attenuation distances. For all other attenuation distances, the limits for the nearest specified IL-values apply, and not by means of interpolating the limits.
A signal can be classified as a “VDSL2-NL1” signal if it is compliant with all clauses below.

2.1.1. Total signal power (downstream only)

To be compliant with this signal category, the mean downstream signal power into a resistive load of 100 Ω shall not exceed the levels given in table 13, measured within a frequency band from at least 4 kHz to 30 MHz. In the special case of VDSL2 deployment from the local exchange, the limits associated with IL=0 apply.

Reference: ITU- T Recommendation G.993.2 [1], chapter 6.

Table 1: Total downstream signal power as function of the measured insertion loss of the loop between local exchange and cabinet.

	IL [dB @ 300 kHz]	Downstream Total signal power [dBm]		L [m]	
	0	21,28		0	
	1	20,11		101	
	2	19,02		202	
	3	18,02		303	
	4	17,09		404	
	5	16,26		506	
	6	15,51		607	
	7	14,85		708	
	8	14,27		809	
	9	13,77		910	
	10	13,37		1011	
	11	12,95		1112	
	12	12,65		1213	
	13	12,4		1315	
	14	12,2		1416	
	15	12,04		1517	
	16	11,91		1618	
	17	11,81		1719	
	18	11,73		1820	
	19	11,66		1921	
	20	11,6		2022	
	21	11,55		2123	
	22	11,52		2225	
	23	11,48		2326	
	24	11,46		2427	
	25	11,7		2528	
	26	11,91		2629	
	27	12,15		2730	
	28	12,36		2831	
	29	12,55		2932	
	30	12,7		3034	
	31	12,82		3135	
	32	12,98		3236	
	33	13,15		3337	
	34	13,32		3438	
	35	13,56		3539	
	36	13,8		3640	
	37	14,03		3741	
	38	14,36		3842	
	39	14,67		3944	
	40	14,98		4045	
	41	15,36		4146	
	42	16,07		4247	
	43	16,63		4348	
	44	17,11		4449	
	45	17,49		4550	
	>45	17,5		>4550	

NOTE 1: The IL-values are normative. The L-values are informative and represent estimated loop lengths for a commonly used Dutch cable.

NOTE 2: Current implementations of VDSL2 transmitters, compliant with [1], are not expected to be capable of generating output powers of more then 20,5 dBm

NOTE 3: The power limit specified for IL>45 dB may be too restrictive for VDSL2; refinement is for further study.

2.1.2. Total signal power (upstream only)

To be compliant with this signal category, the mean upstream signal power into a resistive load of 100 Ω shall not exceed a level of +14,5 dBm, measured within a frequency band from at least 4 kHz to 30 MHz.

NOTE: This power limit is based on maxima specified in [1]. The use of (mandatory) upstream Power Back-off is foreseen, but left for further study

Reference: ITU- T Recommendation G.993.2 [1], chapter 6.

2.1.3. Peak amplitude (upstream and downstream)

To be compliant with this signal category, the nominal voltage peak of the largest signal pulse into a resistive load of 100 Ω shall not exceed a level of 19V (38 V peak-peak), measured within a frequency band from at least 100 Hz to 30 MHz. The definition and measurement method of peak amplitude is specified in clause 13.1.

2.1.4. Narrow-band signal power (downstream only)

To be compliant with this signal category, the Narrow-Band Signal Power (NBSP) into a resistive load impedance ***R*** for a given attenuation distance, shall not exceed the limits given in table 2 and 3, at any point in the frequency range 100 Hz to 30 MHz. These tables specify the break points of these limits. Limits for intermediate frequencies can be found by drawing a straight line between the break points on a logarithmic (Hz) - linear (dB) scale below 2500 kHz and on a linear (Hz) - linear (dB) scale above 2500 kHz. Figure 1 and 2 illustrate the NBSP in a bandwidth-normalized way. The NBSP is the average power ***P*** of a sending signal into a load resistance ***R***, within a *power* bandwidth ***B***. The measurement method of the NBSP is described in clause 13.2.

NOTE 1: The NBSP specification in table 2 is reconstructed from the commonly used PSD specifications in [1] (similar to figure 1), and used here since it is much wider applicable. This enables a unified specification method. PSD specifications are adequate when signals are purely random in nature, but cannot cover harmonic components in a signal (would cause infinite high "PSD" levels at these harmonic frequencies). NBSP specifications cover both signal types.

NOTE 2: The NBSP specification of this signal category has been split into three overlapping limits: "X", “Y” and "Z". All these upper limits shall hold simultaneously. The 10 kHz bandwidth values represent the "peak PSD values" from [1], and includes the pass band ripple. The 100 kHz bandwidth values represent the "nomanal PSD values" in the passband to smooth out the spectral ripple of 3,5 dB. The 1 MHz bandwidth specification is equivalent to the sliding window specification, being common for ADSL (see 4 and 3).

NOTE 3: The description of this signal characteristic is derived from “VDSL2 band plan 998” signals with PSD mask “B8-4”. Downstream PSD Shaping has been applied between 80 KHz and 2500 kHz.

Reference: ITU-T Recommendation G.993.2 [1], clause B.2.5.

Table 2 Break points of the narrow-band power limits

Centre frequency f	Impedance R	Signal Level P	Power bandwidth B	Spectral Power P/B	
0,1 kHz	600 Ω	–77,5 dBm	100 Hz	–97,5 dBm/Hz	"X"
4 kHz	600 Ω	–77,5 dBm	100 Hz	–97,5 dBm/Hz	
4 kHz	100 Ω	–52,5 dBm	10 kHz	–92,5 dBm/Hz	
f_1	100 Ω	P_1 + 40 dB	10 kHz	P_1	
f_2	100 Ω	P_2 + 40 dB	10 kHz	P_2	
f_3	100 Ω	P_3 + 40 dB	10 kHz	P_3	
f_4	100 Ω	P_4 + 40 dB	10 kHz	P_4	
f_5	100 Ω	P_5 + 40 dB	10 kHz	P_5	
f_6	100 Ω	P_6 + 40 dB	10 kHz	P_6	
f_7	100 Ω	P_7 + 40 dB	10 kHz	P_7	
f_8	100 Ω	P_8 + 40 dB	10 kHz	P_8	
f_9	100 Ω	P_9 + 40 dB	10 kHz	P_9	
f_{10}	100 Ω	P_{10} + 40 dB	10 kHz	P_{10}	
f_{11}	100 Ω	P_{11} + 40 dB	10 kHz	P_{11}	
f_{12}	100 Ω	P_{12} + 40 dB	10 kHz	P_{12}	
f_{13}	100 Ω	P_{13} + 40 dB	10 kHz	P_{13}	
f_{14}	100 Ω	P_{14} + 40 dB	10 kHz	P_{14}	
2500 kHz	100 Ω	–8,8 dBm	10 kHz	–48,8 dBm/Hz	
3749,999 kHz	100 Ω	–11,2 dBm	10 kHz	–51,2 dBm/Hz	
3750 kHz	100 Ω	–40 dBm	10 kHz	–80 dBm/Hz	
3925 kHz	100 Ω	–60 dBm	10 kHz	–100 dBm/Hz	
4925 kHz	100 Ω	–60 dBm	10 kHz	–100 dBm/Hz	
5025 kHz	100 Ω	–60 dBm	10 kHz	–100 dBm/Hz	
5199,999 kHz	100 Ω	–40 dBm	10 kHz	–80 dBm/Hz	
5200 kHz	100 Ω	–12,7 dBm	10 kHz	–52,7 dBm/Hz	
8499,999 kHz	100 Ω	–14,8 dBm	10 kHz	–54,8 dBm/Hz	
8500 kHz	100 Ω	–40 dBm	10 kHz	–80 dBm/Hz	
8675 kHz	100 Ω	–60 dBm	10 kHz	–100 dBm/Hz	
30000 kHz	100 Ω	–60 dBm	10 kHz	–100 dBm/Hz	
50 kHz	100 Ω	–46 dBm	100 kHz	–96 dBm/Hz	"Y"
f_1	100 Ω	P_1 + 46,5 dB	100 kHz	P_1 –3,5 dB	
f_2	100 Ω	P_2 + 46,5 dB	100 kHz	P_2 –3,5 dB	
f_3	100 Ω	P_3 + 46,5 dB	100 kHz	P_3 –3,5 dB	
f_4	100 Ω	P_4 + 46,5 dB	100 kHz	P_4 –3,5 dB	
f_5	100 Ω	P_5 + 46,5 dB	100 kHz	P_5 –3,5 dB	
f_6	100 Ω	P_6 + 46,5 dB	100 kHz	P_6 –3,5 dB	
f_7	100 Ω	P_7 + 46,5 dB	100 kHz	P_7 –3,5 dB	
f_8	100 Ω	P_8 + 46,5 dB	100 kHz	P_8 –3,5 dB	
f_9	100 Ω	P_9 + 46,5 dB	100 kHz	P_9 –3,5 dB	
f_{10}	100 Ω	P_{10} + 46,5 dB	100 kHz	P_{10} –3,5 dB	
f_{11}	100 Ω	P_{11} + 46,5 dB	100 kHz	P_{11} –3,5 dB	
f_{12}	100 Ω	P_{12} + 46,5 dB	100 kHz	P_{12} –3,5 dB	
f_{13}	100 Ω	P_{13} + 46,5 dB	100 kHz	P_{13} –3,5 dB	
f_{14}	100 Ω	P_{14} + 46,5 dB	100 kHz	P_{14} –3,5 dB	
2500 kHz	100 Ω	–2,3 dBm	100 kHz	–52,3 dBm/Hz	
3749,999 kHz	100 Ω	–4,5 dBm	100 kHz	–54,7 dBm/Hz	
3750 kHz	100 Ω	–33,5 dBm	100 kHz	–83,5 dBm/Hz	
3894 kHz	100 Ω	–50 dBm	100 kHz	–100 dBm/Hz	
3999,999 kHz	100 Ω	–50 dBm	100 kHz	–100 dBm/Hz	
4000 kHz	100 Ω	–60 dBm	100 kHz	–110 dBm/Hz	
5055 kHz	100 Ω	–60 dBm	100 kHz	–110 dBm/Hz	
5056 kHz	100 Ω	–62 dBm	100 kHz	–99,9 dBm/Hz	
5199,999 kHz	100 Ω	–33,5 dBm	100 kHz	–83,5 dBm/Hz	
5200 kHz	100 Ω	–6,2 dBm	100 kHz	–56,2 dBm/Hz	
8499,999 kHz	100 Ω	–8,3 dBm	100 kHz	–58,3 dBm/Hz	
8500 kHz	100 Ω	–33,5 dBm	100 kHz	–83,5 dBm/Hz	
8644 kHz	100 Ω	–50 dBm	100 kHz	–100 dBm/Hz	
8645 kHz	100 Ω	–60 dBm	100 kHz	–110 dBm/Hz	

Centre frequency f	Impedance R	Signal Level P	Power bandwidth B	Spectral Power P/B	
30000 kHz	100 Ω	–60 dBm	100 kHz	–110 dBm/Hz	
9145 kHz 30000 kHz	100 Ω 100 Ω	–52 dBm –52 dBm	1 MHz 1 MHz	–112 dBm/Hz –112 dBm/Hz	"Z"
Note 1: The limits between breakpoints shall be obtained by interpolation between adjacent breakpoints on a dB/ log(f) basis below 2500 kHz and on a dB/f basis above 2500 kHz Note 2: The limits "Y" between 50 kHz and 2500 kHz are 3,5 dB lower then the associated limits "X". This may be a bit too restrictive for VDSL2 when the PSD slope in this shaping region becomes steep. Refinements for the limits at these breakpoints require further study.					

Table 3: Definition of parameter f_i and P_i, (with i = 1 to 14) as used in table 2.

IL		f_1 P_1	f_2 P_2	f_3 P_3	f_4 P_4	f_5 P_5	f_6 P_6	f_7 P_7	f_8 P_8	f_9 P_9	f_{10} P_{10}	f_{11} P_{11}	f_{12} P_{12}	f_{13} P_{13}	f_{14} P_{14}
0	f	80	137,999	138	1104	1622	2208	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	P	–72,5	–44,2	–36,5	–36,5	–46,5	–48	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
1	f	80	137,999	138	600	1104	1622	2208	2211	N/A	N/A	N/A	N/A	N/A	N/A
	P	–72,5	–44,2	–37,1	–37,7	–38,2	–48,6	–50,3	–48	N/A	N/A	N/A	N/A	N/A	N/A
2	f	80	137,999	138	250	600	1104	1622	2208	2214	N/A	N/A	N/A	N/A	N/A
	P	–72,5	–44,2	–37,6	–38	–38,9	–39,8	–50,6	–52,7	–48	N/A	N/A	N/A	N/A	N/A
3	f	80	137,999	138	250	400	600	850	1104	1622	2208	2217	N/A	N/A	N/A
	P	–72,5	–44,2	–38,2	–38,8	–39,5	–40,1	–40,9	–41,5	–52,7	–55,2	–48	N/A	N/A	N/A
4	f	80	137,999	138	250	400	600	850	1104	1622	2208	2220	N/A	N/A	N/A
	P	–72,5	–44,2	–38,7	–39,5	–40,4	–41,4	–42,3	–43,2	–54,8	–57,6	–48	N/A	N/A	N/A
5	f	80	137,999	138	250	400	600	850	1104	1350	1622	2208	2223	N/A	N/A
	P	–72,5	–44,2	–39,3	–40,3	–41,4	–42,6	–43,8	–44,9	–51,1	–56,8	–60,1	–48,1	N/A	N/A
6	f	80	137,999	138	250	400	600	850	1104	1350	1622	2208	2226	N/A	N/A
	P	–72,5	–44,2	–39,8	–41,1	–42,4	–43,8	–45,2	–46,5	–52,9	–58,9	–62,5	–48,1	N/A	N/A
7	f	80	137,999	138	250	400	600	850	1104	1350	1622	2208	2229	N/A	N/A
	P	–72,5	–44,2	–40,4	–41,8	–43,4	–45	–46,7	–48,2	–54,8	–61	–65	–48,2	N/A	N/A
8	f	80	137,999	138	250	400	600	850	1104	1350	1622	2208	2232	N/A	N/A
	P	–72,5	–44,2	–41	–42,6	–44,4	–46,2	–48,1	–49,9	–56,7	–63	–67,5	–48,3	N/A	N/A
9	f	80	137,999	138	250	400	600	850	1104	1350	1622	2208	2235	N/A	N/A
	P	–72,5	–44,2	–41,5	–43,3	–45,4	–47,4	–49,6	–51,6	–58,5	–65,1	–69,9	–48,3	N/A	N/A
10	f	80	137,999	138	250	400	600	850	1104	1350	1622	2208	2239	N/A	N/A
	P	–72,5	–44,2	–42,1	–44,1	–46,4	–48,7	–51,1	–53,3	–60,5	–67,3	–72,5	–48,1	N/A	N/A
11	f	80	137,999	138	250	400	600	850	1104	1350	1622	2208	2242	N/A	N/A
	P	–72,5	–44,2	–42,7	–45	–47,5	–50,1	–52,8	–55,2	–62,6	–69,6	–75,3	–48,2	N/A	N/A
12	f	80	137,999	138	250	400	600	850	1104	1350	1622	2208	2246	N/A	N/A
	P	–72,5	–44,2	–43,4	–45,8	–48,6	–51,5	–54,4	–57,1	–64,7	–71,9	–78,1	–48,1	N/A	N/A
13	f	80	137,999	138	250	400	600	850	1104	1350	1622	2198	2208	2248	N/A
	P	–72,5	–44,2	–44	–46,7	–49,7	–52,8	–56	–58,9	–66,8	–74,2	–80,6	–80	–48,1	N/A
14	f	80	137	250	400	600	850	1104	1350	1622	2162	2208	2248	N/A	N/A
	P	–72,5	–44,6	–47,5	–50,7	–54,1	–57,6	–60,7	–68,8	–76,4	–82,9	–80	–48,1	N/A	N/A
15	f	80	136	138	250	400	600	850	1104	1350	1622	2129	2208	2248	N/A
	P	–72,5	–45,1	–45,1	–48,3	–51,8	–55,4	–59,1	–62,5	–70,7	–78,6	–85,1	–80	–48,1	N/A
16	f	80	134	138	250	400	600	850	1104	1350	1622	2097	2208	2248	N/A
	P	–72,5	–45,7	–45,7	–49,1	–52,8	–56,6	–60,6	–64,2	–72,6	–80,7	–87,2	–80	–48,1	N/A
17	f	80	133	138	250	400	600	850	1104	1350	1622	2067	2208	2248	N/A
	P	–72,5	–46,3	–46,3	–49,8	–53,8	–57,8	–62	–65,9	–74,5	–82,8	–89,2	–80	–48,1	N/A
18	f	80	131	138	250	400	600	850	1104	1350	1622	2039	2208	2248	N/A
	P	–72,5	–46,9	–46,8	–50,6	–54,7	–59	–63,5	–67,5	–76,3	–84,8	–91,1	–80	–48,1	N/A
19	f	80	130	138	250	400	600	850	1104	1350	1622	1912	2033	2208	2248
	P	–72,5	–47,3	–47,3	–51,3	–55,7	–60,2	–64,9	–69,1	–78,1	–86,7	–91,5	–91,5	–80	–48,1
20	f	80	129	138	250	400	600	850	1104	1350	1622	1782	2033	2208	2248
	P	–72,5	–47,9	–47,9	–52	–56,6	–61,3	–66,2	–70,6	–79,8	–88,7	–91,5	–91,5	–80	–48,1
21	f	80	127	138	250	400	600	850	1104	1350	1622	1673	2033	2208	2248
	P	–72,5	–48,5	–48,4	–52,7	–57,5	–62,4	–67,5	–72,2	–81,5	–90,5	–91,5	–91,5	–80	–48,1
22	f	80	126	138	250	400	600	850	1104	1350	1594	2033	2208	2248	N/A
	P	–72,5	–48,9	–48,9	–53,3	–58,3	–63,5	–68,8	–73,6	–83,2	–91,5	–91,5	–80	–48,1	N/A
23	f	80	125	138	250	400	600	850	1104	1350	1540	2033	2208	2248	N/A

IL		f_1 P_1	f_2 P_2	f_3 P_3	f_4 P_4	f_5 P_5	f_6 P_6	f_7 P_7	f_8 P_8	f_9 P_9	f_{10} P_{10}	f_{11} P_{11}	f_{12} P_{12}	f_{13} P_{13}	f_{14} P_{14}
	P	–72,5	–49,3	–49,3	–54	–59,2	–64,5	–70,1	–75,1	–84,8	–91,5	–91,5	–80	–48,1	N/A
24	f	80	124	138	250	400	600	850	1104	1350	1491	2031	2206	2246	N/A
	P	–72,5	–49,8	–49,8	–54,6	–60	–65,5	–71,3	–76,5	–86,3	–91,5	–91,5	–80	–48,1	N/A
25	f	80	123	138	250	400	600	850	1104	1350	1447	1911	2086	2126	2208
	P	–72,5	–50,3	–50,3	–55,2	–60,8	–66,5	–72,5	–77,8	–87,8	–91,5	–91,5	–80	–47,8	–48
26	f	80	122	138	250	400	600	850	1104	1350	1406	1807	1982	2022	2208
	P	–72,5	–50,7	–50,7	–55,8	–61,6	–67,5	–73,6	–79,2	–89,3	–91,5	–91,5	–80	–47,6	–48
27	f	80	121	138	250	400	600	850	1104	1369	1693	1868	1908	2208	N/A
	P	–72,5	–51,1	–51,1	–56,4	–62,3	–68,4	–74,7	–80,4	–91,5	–91,5	–80	–47,3	–48	N/A
28	f	80	120	138	250	400	600	850	1104	1334	1593	1768	1808	2208	N/A
	P	–72,5	–51,5	–51,5	–57	–63,1	–69,3	–75,8	–81,7	–91,5	–91,5	–80	–47	–48	N/A
29	f	80	119	138	250	400	600	850	1104	1301	1505	1680	1720	2208	N/A
	P	–72,5	–51,9	–51,9	–57,5	–63,8	–70,2	–76,8	–82,9	–91,5	–91,5	–80	–46,8	–48	N/A
30	f	80	118	138	250	400	600	850	1104	1270	1433	1608	1648	2208	N/A
	P	–72,5	–52,3	–52,3	–58,1	–64,5	–71	–77,9	–84	–91,5	–91,5	–80	–46,6	–48	N/A
31	f	80	117	138	250	400	600	850	1104	1240	1380	1555	1595	1622	2208
	P	–72,5	–52,8	–52,7	–58,6	–65,2	–71,9	–78,9	–85,2	–91,5	–91,5	–80	–46,1	–46,5	–48
32	f	80	116	138	250	400	600	850	1104	1205	1322	1497	1538	1622	2208
	P	–72,5	–53,2	–53,2	–59,3	–66	–73	–80,2	–86,7	–91,5	–91,5	–80	–45,1	–46,5	–48
33	f	80	115	138	250	400	600	850	1104	1172	1268	1443	1485	1622	2208
	P	–72,5	–53,7	–53,7	–59,9	–66,9	–74	–81,5	–88,2	–91,5	–91,5	–80	–44,2	–46,5	–48
34	f	80	114	138	250	400	600	850	1104	1141	1217	1392	1434	1622	2208
	P	–72,5	–54,2	–54,2	–60,6	–67,8	–75,1	–82,7	–89,6	–91,5	–91,5	–80	–43,6	–46,5	–48
35	f	80	113	138	250	400	600	850	1104	1111	1169	1344	1387	1622	2208
	P	–72,5	–54,7	–54,7	–61,3	–68,6	–76,2	–84	–91,1	–91,5	–91,5	–80	–42,4	–46,5	–48
36	f	80	112	138	250	400	600	850	1061	1122	1297	1341	1622	2208	N/A
	P	–72,5	–55,2	–55,2	–61,9	–69,5	–77,2	–85,3	–91,5	–91,5	–80	–41,6	–46,5	–48	N/A
37	f	80	111	138	250	400	600	850	1009	1077	1252	1296	1622	2208	N/A
	P	–72,5	–55,7	–55,7	–62,6	–70,4	–78,3	–86,6	–91,5	–91,5	–80	–41	–46,5	–48	N/A
38	f	80	110	138	250	400	600	850	962	1036	1211	1256	1622	2208	N/A
	P	–72,5	–56,2	–56,2	–63,3	–71,2	–79,4	–87,9	–91,5	–91,5	–80	–39,9	–46,5	–48	N/A
39	f	80	109	138	250	400	600	850	919	996	1171	1217	1622	2208	N/A
	P	–72,5	–56,6	–56,6	–63,9	–72,1	–80,5	–89,2	–91,5	–91,5	–80	–39	–46,5	–48	N/A
40	f	80	108	138	250	400	600	850	880	959	1134	1180	1622	2208	N/A
	P	–72,5	–57,1	–57,1	–64,6	–73	–81,5	–90,4	–91,5	–91,5	–80	–38,3	–46,5	–48	N/A
41	f	80	107	138	250	400	600	843	921	1096	1143	1622	2208	N/A	N/A
	P	–72,5	–57,6	–57,6	–65,3	–73,8	–82,6	–91,5	–91,5	–80	–37,4	–46,5	–48	N/A	N/A
42	f	80	106	138	250	400	600	803	857	1032	1079	1104	1622	2208	N/A
	P	–72,5	–58,1	–58,1	–66	–74,7	–83,7	–91,5	–91,5	–80	–36,5	–36,5	–46,5	–48	N/A
43	f	80	105	138	250	400	600	768	800	975	1021	1104	1622	2208	N/A
	P	–72,5	–58,6	–58,6	–66,6	–75,6	–84,8	–91,5	–91,5	–80	–36,7	–36,5	–46,5	–48	N/A
44	f	80	104	138	250	400	600	735	749	924	970	1104	1622	2208	N/A
	P	–72,5	–59,1	–59,1	–67,3	–76,4	–85,8	–91,5	–91,5	–80	–36,5	–36,5	–46,5	–48	N/A
45	f	80	103	138	250	400	600	703	877	922	1104	1622	2208	N/A	N/A
	P	–72,5	–59,6	–59,6	–68	–77,3	–86,9	–91,4	–80	–36,5	–36,5	–46,5	–48	N/A	N/A
>45	f	80	103	138	250	400	600	703	877	922	1104	1622	2208	N/A	N/A
	P	–91,5	–91,5	–91,5	–91,5	–91,5	–91,5	–91,4	–80	–36,5	–36,5	–46,5	–48	N/A	N/A

NOTE 1: The label "N/A" denotes that a breakpoint is not used. The equivalent physical cable length L of the cable (last column of the table) is for information only, and estimated from a 0.5 mm GPLK cable model (model "KPN_L1", also known as "TP 150" in [2]).

NOTE 2: The breakpoints for IL > 45 dB may be too restrictive for VDSL2, refinements are for further study.

In the special case that VDSL2 is deployed from the local exchange, the attenuation length is zero (IL=0), and the associated rows from the table apply. Figure 1 illustrates the limits of the spectral powers (measured in 10 kHz and in 100 kHz) as function of the frequency, according to the specifications in table 2 and 3.

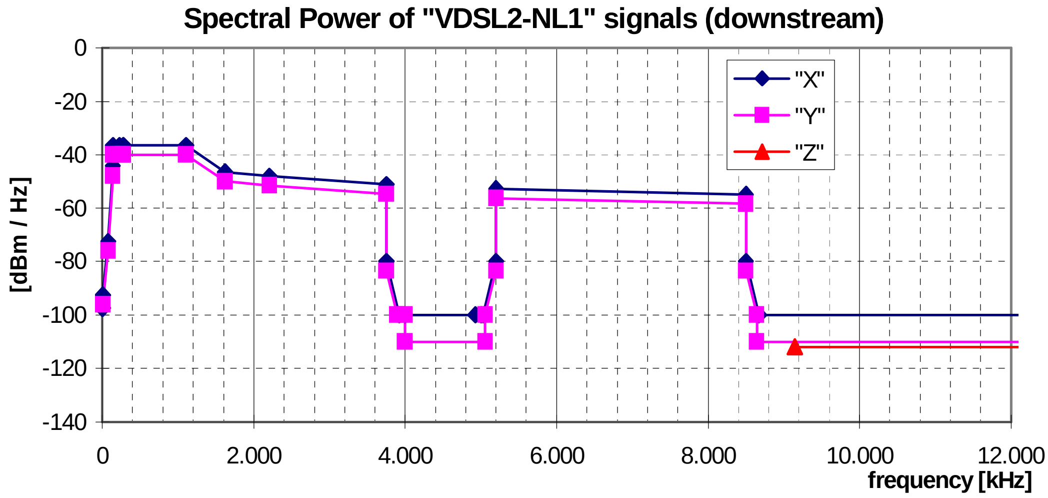

Figure 1: Spectral Power for “VDSL2-NL1” signals, as specified in table 2 and 3 for IL=0 dB.

When VDSL2 is deployed from the cabinet, shaping of the above spectral powers between 134 kHz and 2500 kHz can be significant. Figure 2 illustrates the limits of these spectral powers (measured in 10 kHz and in 100 kHz) for various attenuation distances (for IL =10 dB, IL=20 dB and IL=40 dB).

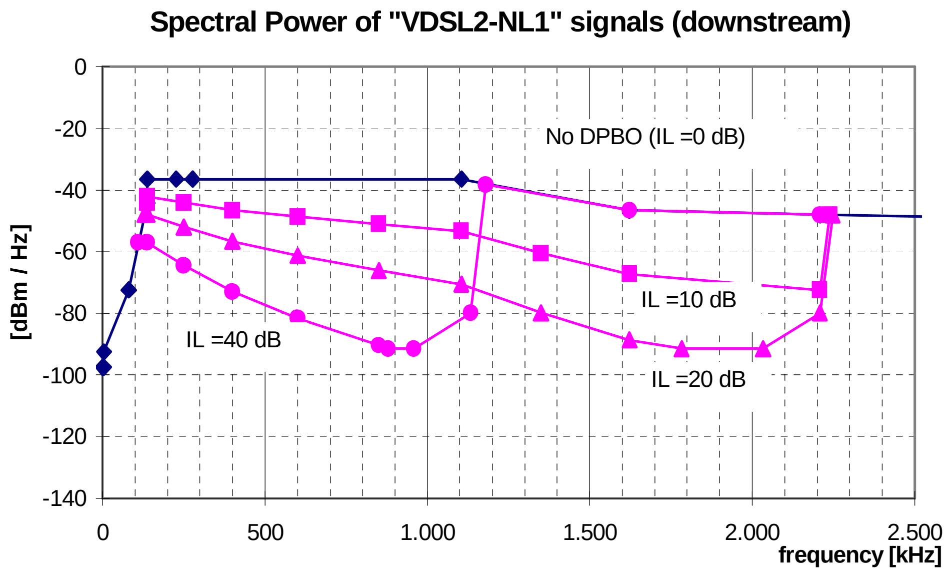

Figure 2: Spectral Power for “VDSL2-NL1” signals, as specified in table 2 and 3, for a frequency band where downstream PSD Shaping has been applied.

2.1.5. Narrow-band signal power (upstream only)

To be compliant with this signal category, the Narrow-Band Signal Power (NBSP) into a resistive load impedance R, shall not exceed the limits given in table 4, at any point in the frequency range 100 Hz to 30 MHz. This table specifies the break points of these limits. Limits for intermediate frequencies can be found by drawing a straight line between the break points on a logarithmic (Hz) - linear (dB) scale below 3575 KHz and linear (Hz) - linear (dB) scale above 3575 KHz. Figure 8 illustrates the NBSP in a bandwidth-normalized way.
The NBSP is the average power ***P*** of a sending signal into a load resistance ***R***, within a *power bandwidth* ***B***. The measurement method of the NBSP is described in clause 13.2.

NOTE 1: The NBSP specification in table 4 is reconstructed from the commonly used PSD specifications in [1] (similar to figure 8), and used here since it is much wider applicable. This enables a unified specification method. PSD specifications are adequate when signals are purely random in nature, but cannot cover harmonic components in a signal (would cause infinite high "PSD" levels at these harmonic frequencies). NBSP specifications cover both signal types.

NOTE 2: The NBSP specification of this signal category has been split into three overlapping limits: "X", "Y" and "Z". All three upper limits hold simultaneously. The 10 kHz bandwidth values represent the "maximum PSD values" from [1], and includes the pass band ripple. The 100 kHz bandwidth values represent the "average PSD values" in the pass band to smooth out the spectral ripple of 3,5 dB. The 1 MHz bandwidth specification is equivalent to the sliding window specification being common for ADSL (see [4] and [3]).

NOTE 3: The need for the inclusion of a normative upstream power back-off specification is foreseen. This topic is currently under discussion within ETSI and the ITU, and therefore left for further study in the present document.

Reference: ITU-T Recommendation G.993.2 [1], clause B2.4 reconstructed from PSD requirements.

Table 4: Break points of the narrow-band power limits

Centre frequency f	Impedance R	Signal Level P	Power bandwidth B	Spectral Power P/B	
0,1 kHz	600 Ω	–77,5 dBm	100 Hz	–97,5 dBm/Hz	“X”
4 kHz	600 Ω	–77,5 dBm	100 Hz	–97,5 dBm/Hz	
4 kHz	100 Ω	–52,5 dBm	10 kHz	–92,5 dBm/Hz	
25,875 kHz	100 Ω	+5,5 dBm	10 kHz	–34,5 dBm/Hz	
50 kHz	100 Ω	+5,5 dBm	10 kHz	–34,5 dBm/Hz	
80 kHz	100 Ω	+5,5 dBm	10 kHz	–34,5 dBm/Hz	
120 kHz	100 Ω	+5,5 dBm	10 kHz	–34,5 dBm/Hz	
138 kHz	100 Ω	+5,5 dBm	10 kHz	–34,5 dBm/Hz	
243 kHz	100 Ω	–53,2 dBm	10 kHz	–93,2 dBm/Hz	
686 kHz	100 Ω	–60 dBm	10 kHz	–100 dBm/Hz	
783 kHz	100 Ω	–60 dBm	10 kHz	–100 dBm/Hz	
2825 kHz	100 Ω	–60 dBm	10 kHz	–100 dBm/Hz	
3000 kHz	100 Ω	–60 dBm	10 kHz	–100 dBm/Hz	
3000 kHz	100 Ω	–60 dBm	10 kHz	–100 dBm/Hz	
3575 kHz	100 Ω	–60 dBm	10 kHz	–100 dBm/Hz	
3750 kHz	100 Ω	–40 dBm	10 kHz	–80 dBm/Hz	
3750 kHz	100 Ω	–11,2 dBm	10 kHz	–51,2 dBm/Hz	
5200 kHz	100 Ω	–12,7 dBm	10 kHz	–52,7 dBm/Hz	
5200 kHz	100 Ω	–40 dBm	10 kHz	–80 dBm/Hz	
5375 kHz	100 Ω	–60 dBm	10 kHz	–100 dBm/Hz	
6875 kHz	100 Ω	–60 dBm	10 kHz	–100 dBm/Hz	
7050 kHz	100 Ω	–60 dBm	10 kHz	–100 dBm/Hz	
7050 kHz	100 Ω	–60 dBm	10 kHz	–100 dBm/Hz	
8325 kHz	100 Ω	–60 dBm	10 kHz	–100 dBm/Hz	
8500 kHz	100 Ω	–40 dBm	10 kHz	–80 dBm/Hz	
8500 kHz	100 Ω	–14,8 dBm	10 kHz	–54,8 dBm/Hz	
10000 kHz	100 Ω	–15,5 dBm	10 kHz	–55,5 dBm/Hz	
12000 kHz	100 Ω	–16,5 dBm	10 kHz	–56,5 dBm/Hz	
12000 kHz	100 Ω	–40 dBm	10 kHz	–80 dBm/Hz	
12175 kHz	100 Ω	–60 dBm	10 kHz	–100 dBm/Hz	
14350 kHz	100 Ω	–60 dBm	10 kHz	–100 dBm/Hz	
14351 kHz	100 Ω	–60 dBm	10 kHz	–100 dBm/Hz	
14526 kHz	100 Ω	–60 dBm	10 kHz	–100 dBm/Hz	
30000 kHz	100 Ω	–60 dBm	10 kHz	–100 dBm/Hz	
50 kHz	100 Ω	+12 dBm	100 kHz	–38 dBm/Hz	“Y”
80 kHz	100 Ω	+12 dBm	100 kHz	–38 dBm/Hz	

Centre frequency f	Impedance R	Signal Level P	Power bandwidth B	Spectral Power P/B	
120 kHz	100 Ω	+12 dBm	100 kHz	–38 dBm/Hz	
138 kHz	100 Ω	+12 dBm	100 kHz	–38 dBm/Hz	
243 kHz	100 Ω	–46,7 dBm	100 kHz	–96,7 dBm/Hz	
686 kHz	100 Ω	–50 dBm	100 kHz	–100 dBm/Hz	
783 kHz	100 Ω	–50 dBm	100 kHz	–100 dBm/Hz	
2825 kHz	100 Ω	–50 dBm	100 kHz	–100 dBm/Hz	
2999,999 kHz	100 Ω	–50 dBm	100 kHz	–100 dBm/Hz	
3000 kHz	100 Ω	–50 dBm	100 kHz	–100 dBm/Hz	
3575 kHz	100 Ω	–50 dBm	100 kHz	–100 dBm/Hz	
3749,999 kHz	100 Ω	–33,5 dBm	100 kHz	–83,5 dBm/Hz	
3750 kHz	100 Ω	–5,7 dBm	100 kHz	–54,7 dBm/Hz	
5199,999 kHz	100 Ω	–6,2 dBm	100 kHz	–56,2 dBm/Hz	
5200 kHz	100 Ω	–33,5 dBm	100 kHz	–83,5 dBm/Hz	
5375 kHz	100 Ω	–60 dBm	100 kHz	–110 dBm/Hz	
6875 kHz	100 Ω	–60 dBm	100 kHz	–110 dBm/Hz	
7049,999 kHz	100 Ω	–60 dBm	100 kHz	–110 dBm/Hz	
7050 kHz	100 Ω	–60 dBm	100 kHz	–110 dBm/Hz	
8325 kHz	100 Ω	–60 dBm	100 kHz	–110 dBm/Hz	
8499,999 kHz	100 Ω	–33,5 dBm	100 kHz	–83,5 dBm/Hz	
8500 kHz	100 Ω	–8,3 dBm	100 kHz	–58,3 dBm/Hz	
10000 kHz	100 Ω	–9 dBm	100 kHz	–59 dBm/Hz	
11999,999 kHz	100 Ω	–10 dBm	100 kHz	–60 dBm/Hz	
12000 kHz	100 Ω	–33,5 dBm	100 kHz	–83,5 dBm/Hz	
12175 kHz	100 Ω	–60 dBm	100 kHz	–110 dBm/Hz	
14350 kHz	100 Ω	–60 dBm	100 kHz	–110 dBm/Hz	
14351 kHz	100 Ω	–60 dBm	100 kHz	–110 dBm/Hz	
14526 kHz	100 Ω	–60 dBm	100 kHz	–110 dBm/Hz	
30000 kHz	100 Ω	–60 dBm	100 kHz	–110 dBm/Hz	
12675 kHz	100 Ω	–52 dBm	1 MHz	–112 dBm/Hz	"Z"
14350 kHz	100 Ω	–52 dBm	1 MHz	–112 dBm/Hz	
14351 kHz	100 Ω	–52 dBm	1 MHz	–112 dBm/Hz	
14526 kHz	100 Ω	–52 dBm	1 MHz	–112 dBm/Hz	
30000 kHz	100 Ω	–52 dBm	1 MHz	–112 dBm/Hz	

NOTE 1: The PSD values between breakpoints shall be obtained by interpolation between adjacent breakpoints as follows:

- below *3575* kHz: on a dB / $\log_{10}(f)$ basis and
- above *3575* kHz: on a dB / f basis

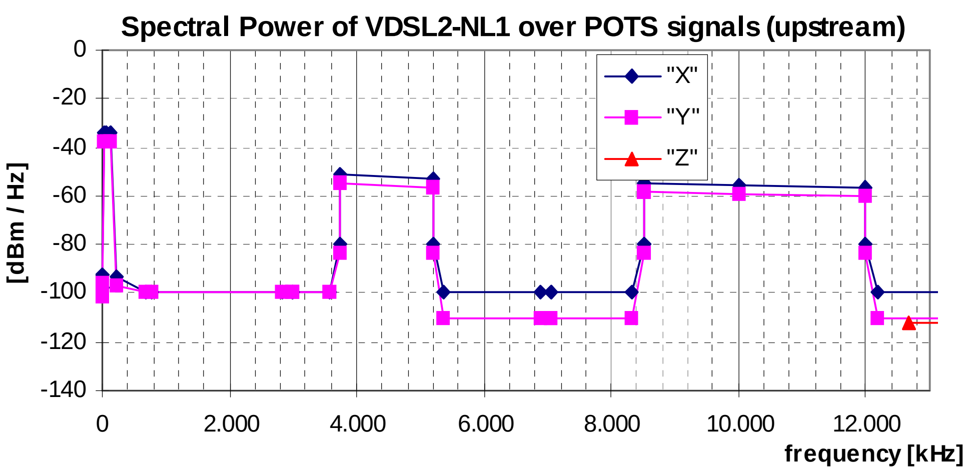

Figure 3: Spectral Power, for "VDSL2-NL1" signals, as specified in table 4.

2.1.6. Unbalance about earth (upstream and downstream)

To be compliant with this signal category, the balance of the signal that may flow through the LT-port or NT-port shall exceed minimum requirements, under the condition that the local loop wiring and its termination is well balanced. This can be verified by a Longitudinal Output Voltage (LOV) and a Longitudinal Conversion Loss (LCL) measurement at the source of that signal, as specified in clause 13.3.2 and 13.3.3. The minimum LOV and LCL requirements hold for what can be observed at the ports of the Local Loop Wiring, when the Local Loop Wiring is replaced by an artificial impedance network described in clause 13.3.2 and 13.3.3.

The differential termination impedance for LOV and LCL measurements shall be chosen equally to the design impedance $R_T = 100\ \Omega$ of the Signal Source under test.

The observed LOV shall have an rms voltage of below the value specified in table 5, measured in a *power* bandwidth B, centred over any frequency in the range from f_{min} to f_{max}, and averaged in any one second period. Compliance with this limitation is required with a longitudinal terminating impedance having value $Z_L(\omega) = R_L + 1 / (j\omega \times C_L)$ for all frequencies between f_{min} to f_{max}. Clause 13.3.2 defines an example measurement method for longitudinal output voltage.

The observed LCL shall be higher than the lower limits given in figure 4. The LCL values of the associated break frequencies of this figure are given in table 6. Clause 13.3.3 defines an example measurement method for longitudinal conversion loss. To be compliant with this signal category, this requirement shall be met for both the switched-on and switched-off mode of the signal source.

Reference: TS 101 270-1, clauses 8.3.3 and E.3.2 [2].

Table 5: Values for the LOV limits

	LOV	B	f_{min}	f_{max}	R_L	C_L
downstream	–46 dBV	10 kHz	5,1 kHz	1 825 kHz	100 Ω	150 nF
upstream	–46 dBV	10 kHz	5,1 kHz	210 kHz	100 Ω	150 nF

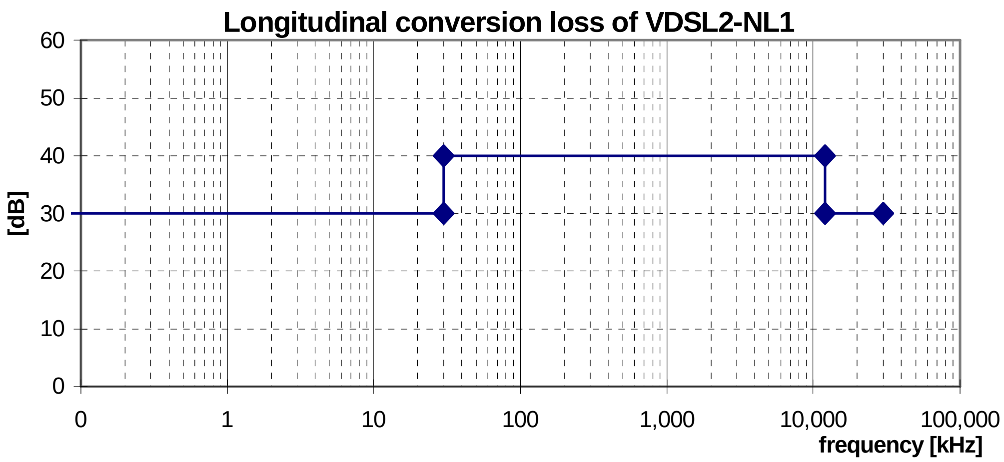

Figure 4: Minimum longitudinal conversion loss

Table 6: Frequencies and LCL values of the breakpoints of the LCL mask in figure 4.

Frequency	LCL
< 30 kHz	30 dB
30 kHz	40 dB
12 MHz	40 dB
12 MHz	30 dB
30 MHz	30 dB

2.2. "VDSL2-NL2” (over ISDN) signals

This category covers signals up to 12 MHz, generated by VDSL2 transmission equipment using band plan 998 (limit PSD mask B8-6). These signals may share the same wire pair with ISDN signals.
This signal description is derived from the ITU VDSL2 recommendation [1], and enhanced by loop dependent PSD shaping, also known as downstream Power Backoff. The signal limits are therefore dependent on the insertion loss (IL) of the loop (“primary cable”) between the local exchange and cabinet, measured at 300 kHz into a resistive load of 100 Ω.
The limits in this description are specified for a discrete number of (integer) IL-values. For all other IL-values, the limits for the nearest specified IL-values apply, and not by means of interpolating limits.
A signal can be classified as a “VDSL2-NL2” (over ISDN) signal if it is compliant with all clauses below.

2.2.1. Total signal power (downstream only)

To be compliant with this signal category, the mean downstream signal power into a resistive load of 100 Ω shall not exceed the levels given in table 8, measured within a frequency band from at least 4 kHz to 30 MHz. In the special case of VDSL2 deployment from the local exchange, the limits associated with IL=0 apply.

Table 8: Total downstream signal power as function of the measured insertion loss of the loop between local exchange and cabinet.

IL [dB @ 300 kHz]	Downstream Total signal power [dBm]	L [m]
0	20,8	0
1	19,5	101
2	18,4	202
3	17,4	303
4	16,4	404
5	15,5	506
6	14,8	607
7	14,1	708
8	13,6	809
9	13,1	910
10	12,7	1011
11	12,4	1112
12	12,1	1213
13	11,9	1315
14	11,8	1416
15	11,7	1517
16	11,6	1618
17	11,5	1719
18	11,5	1820
19	11,4	1921
20	11,4	2022
21	11,4	2123
22	11,4	2225
23	11,3	2326
24	11,3	2427
25	11,6	2528
26	11,8	2629
27	12,1	2730
28	12,3	2831
29	12,5	2932
30	12,6	3034
31	12,8	3135
32	12,9	3236
33	13,1	3337
34	13,3	3438
35	13,5	3539
36	13,8	3640
37	14,0	3741
38	14,3	3842
39	14,7	3944
40	15,0	4045
41	15,4	4146
42	16,1	4247
43	16,6	4348
44	17,1	4449
45	17,5	4550
>45	17,5	>4550

NOTE 1: The IL-values are normative. The L-values are informative and represent estimated loop lengths for a commonly used Dutch cable.

NOTE 2: Current implementations of VDSL2 transmitters, compliant with [1], are not expected to be capable of generating output powers of more then 20,5 dBm

NOTE 3: The power limit specified for IL>45 dB may be too restrictive for VDSL2; refinement is for further study.

2.2.2. Total signal power (upstream only)

To be compliant with this signal category, the mean upstream signal power into a resistive load of 100 Ω shall not exceed a level of +14,5 dBm, measured within a frequency band from at least 4 kHz to 30 MHz.

NOTE: This power limit is based on maxima specified in [1]. The use of (mandatory) upstream Power Back-off is foreseen, but left for further study

Reference: ITU- T Recommendation G.993.2 [1], chapter 6.

2.2.3. Peak amplitude (upstream and downstream)

To be compliant with this signal category, the nominal voltage peak of the largest signal pulse into a resistive load of 100 Ω shall not exceed a level of 19V (38 V peak-peak), measured within a frequency band from at least 100 Hz to 30 MHz. The definition and measurement method of peak amplitude is specified in clause 13.1.

2.2.4. Narrow-band signal power (downstream only)

To be compliant with this signal category, the Narrow-Band Signal Power (NBSP) into a resistive load impedance ***R*** for a given IL-value, shall not exceed the limits given in table 9 and table 10, at any point in the frequency range 100 Hz to 30 MHz. These tables specify the break points of these limits. Limits for intermediate frequencies can be found by drawing a straight line between the break points on a logarithmic (Hz) - linear (dB) scale below 2500 kHz and on a linear (Hz) - linear (dB) scale above 2500 kHz. Figure 5 and figure 6 illustrate the NBSP in a bandwidth-normalized way. The NBSP is the average power ***P*** of a sending signal into a load resistance ***R***, within a *power* bandwidth ***B***. The measurement method of the NBSP is described in clause 13.2.

NOTE 1: The NBSP specification in table 9 is reconstructed from the commonly used PSD specifications in [1] (similar to figure 5), and used here since it is much wider applicable. This enables a unified specification method. PSD specifications are adequate when signals are purely random in nature, but cannot cover harmonic components in a signal (would cause infinite high "PSD" levels at these harmonic frequencies). NBSP specifications cover both signal types.

NOTE 2: The NBSP specification of this signal category has been split into three overlapping limits: "X", “Y” and "Z". All these upper limits shall hold simultaneously. The 10 kHz bandwidth values represent the "maximum PSD values" [1], and includes the pass band ripple. The 100 kHz bandwidth values represent the "average PSD values" in the passband to smooth out the spectral ripple of 3,5 dB. The 1 MHz bandwidth specification is equivalent to the sliding window specification being common for ADSL (see [**4**] and [3]).

Reference: ITU-T Recommendation G.993.2 [1], clause B.2.5.

The description of this signal characteristic is derived from VDSL2 “band plan 998” signals with PSD mask “B8-6”. Downstream PSD Shaping has been applied between 101.2 KHz and 2500 kHz.

Table 9: Break points of the narrow-band power limits

Centre frequency f	Impedance R	Signal Level P	Power bandwidth B	Spectral Power P/B	
0,1 kHz	600 Ω	–77,5 dBm	100 Hz	–97,5 dBm/Hz	"X"
4 kHz	600 Ω	–77,5 dBm	100 Hz	–97,5 dBm/Hz	
4 kHz	100 Ω	–52,5 dBm	10 kHz	–92,5 dBm/Hz	
80 kHz	100 Ω	–52,5 dBm	10 kHz	–92,5 dBm/Hz	
f_1	100 Ω	P_1 + 40 dB	10 kHz	P_1	
f_2	100 Ω	P_2 + 40 dB	10 kHz	P_2	
f_3	100 Ω	P_3 + 40 dB	10 kHz	P_3	
f_4	100 Ω	P_4 + 40 dB	10 kHz	P_4	
f_5	100 Ω	P_5 + 40 dB	10 kHz	P_5	
f_6	100 Ω	P_6 + 40 dB	10 kHz	P_6	
f_7	100 Ω	P_7 + 40 dB	10 kHz	P_7	
f_8	100 Ω	P_8 + 40 dB	10 kHz	P_8	
f_9	100 Ω	P_9 + 40 dB	10 kHz	P_9	
f_{10}	100 Ω	P_{10} + 40 dB	10 kHz	P_{10}	
f_{11}	100 Ω	P_{11} + 40 dB	10 kHz	P_{11}	
f_{12}	100 Ω	P_{12} + 40 dB	10 kHz	P_{12}	
f_{13}	100 Ω	P_{13} + 40 dB	10 kHz	P_{13}	
f_{14}	100 Ω	P_{14} + 40 dB	10 kHz	P_{14}	
2500 kHz	100 Ω	–8,8 dBm	10 kHz	–48,8 dBm/Hz	
3749,999 kHz	100 Ω	–11,2 dBm	10 kHz	–51,2 dBm/Hz	
3750 kHz	100 Ω	–40 dBm	10 kHz	–80 dBm/Hz	
3925 kHz	100 Ω	–60 dBm	10 kHz	–100 dBm/Hz	
4925 kHz	100 Ω	–60 dBm	10 kHz	–100 dBm/Hz	
5025 kHz	100 Ω	–60 dBm	10 kHz	–100 dBm/Hz	
5199,999 kHz	100 Ω	–40 dBm	10 kHz	–80 dBm/Hz	
5200 kHz	100 Ω	–12,7 dBm	10 kHz	–52,7 dBm/Hz	
8499,999 kHz	100 Ω	–14,8 dBm	10 kHz	–54,8 dBm/Hz	
8500 kHz	100 Ω	–40 dBm	10 kHz	–80 dBm/Hz	
8675 kHz	100 Ω	–60 dBm	10 kHz	–100 dBm/Hz	
30000 kHz	100 Ω	–60 dBm	10 kHz	–100 dBm/Hz	
50 kHz	100 Ω	–46 dBm	100 kHz	–96 dBm/Hz	"Y"
80 kHz	100 Ω	–46 dBm	100 kHz	–96 dBm/Hz	
f_1	100 Ω	P_1 + 46,5 dB	100 kHz	P_1 –3,5 dB	
f_2	100 Ω	P_2 + 46,5 dB	100 kHz	P_2 –3,5 dB	
f_3	100 Ω	P_3 + 46,5 dB	100 kHz	P_3 –3,5 dB	
f_4	100 Ω	P_4 + 46,5 dB	100 kHz	P_4 –3,5 dB	
f_5	100 Ω	P_5 + 46,5 dB	100 kHz	P_5 –3,5 dB	
f_6	100 Ω	P_6 + 46,5 dB	100 kHz	P_6 –3,5 dB	
f_7	100 Ω	P_7 + 46,5 dB	100 kHz	P_7 –3,5 dB	
f_8	100 Ω	P_8 + 46,5 dB	100 kHz	P_8 –3,5 dB	
f_9	100 Ω	P_9 + 46,5 dB	100 kHz	P_9 –3,5 dB	
f_{10}	100 Ω	P_{10} + 46,5 dB	100 kHz	P_{10} –3,5 dB	
f_{11}	100 Ω	P_{11} + 46,5 dB	100 kHz	P_{11} –3,5 dB	
f_{12}	100 Ω	P_{12} + 46,5 dB	100 kHz	P_{12} –3,5 dB	
f_{13}	100 Ω	P_{13} + 46,5 dB	100 kHz	P_{13} –3,5 dB	
f_{14}	100 Ω	P_{14} + 46,5 dB	100 kHz	P_{14} –3,5 dB	
2500 kHz	100 Ω	–2,3 dBm	100 kHz	–52,3 dBm/Hz	
3749,999 kHz	100 Ω	–4,5 dBm	100 kHz	–54,7 dBm/Hz	
3750 kHz	100 Ω	–33,5 dBm	100 kHz	–83,5 dBm/Hz	
3894 kHz	100 Ω	–50 dBm	100 kHz	–100 dBm/Hz	
3999,999 kHz	100 Ω	–50 dBm	100 kHz	–100 dBm/Hz	
4000 kHz	100 Ω	–60 dBm	100 kHz	–110 dBm/Hz	
5055 kHz	100 Ω	–60 dBm	100 kHz	–110 dBm/Hz	
5056 kHz	100 Ω	–62 dBm	100 kHz	–99,9 dBm/Hz	
5199,999 kHz	100 Ω	–33,5 dBm	100 kHz	–83,5 dBm/Hz	
5200 kHz	100 Ω	–6,2 dBm	100 kHz	–56,2 dBm/Hz	
8499,999 kHz	100 Ω	–8,3 dBm	100 kHz	–58,3 dBm/Hz	
8500 kHz	100 Ω	–33,5 dBm	100 kHz	–83,5 dBm/Hz	

Centre frequency f	Impedance R	Signal Level P	Power bandwidth B	Spectral Power P/B	
8644 kHz	100 Ω	–50 dBm	100 kHz	–100 dBm/Hz	
8645 kHz	100 Ω	–60 dBm	100 kHz	–110 dBm/Hz	
30000 kHz	100 Ω	–60 dBm	100 kHz	–110 dBm/Hz	
9145 kHz	100 Ω	–52 dBm	1 MHz	–112 dBm/Hz	“Z”
30000 kHz	100 Ω	–52 dBm	1 MHz	–112 dBm/Hz	
Note 1: The limits between breakpoints shall be obtained by interpolation between adjacent breakpoints on a dB/ log(f) basis below 2500 kHz and on a dB/f basis above 2500 kHz Note 2: The limits “Y” between 50 kHz and 2500 kHz are 3,5 dB lower then the associated limits “X”. This may be a bit too restrictive for VDSL2 when the PSD slope in this shaping region becomes steep. Refinements for the limits at these breakpoints require further study.					

Table 10: Definition of parameter f_i and P_i, (with i = 1 to 14) as used in table 9. Note: N/A in the table denotes that a breakpoint is not used.

IL		f_1 P_1	f_2 P_2	f_3 P_3	f_4 P_4	f_5 P_5	f_6 P_6	f_7 P_7	f_8 P_8	f_9 P_9	f_{10} P_{10}	f_{11} P_{11}	f_{12} P_{12}	f_{13} P_{13}	f_{14} P_{14}
0	f	101.2	227.11	275.999	276	1104	1622	2208	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	P	–92.5	–62	–48.5	–36.5	–36.5	–46.5	–48	N/A	N/A	N/A	N/A	N/A	N/A	N/A
1	f	101.2	227.11	275.999	276	850	1104	1622	2208	2211	N/A	N/A	N/A	N/A	N/A
	P	–92.5	–62	–48.5	–37.3	–38	–38.2	–48.6	–50.3	–48	N/A	N/A	N/A	N/A	N/A
2	f	101.2	227.11	275.999	276	600	1104	1622	2208	2214	N/A	N/A	N/A	N/A	N/A
	P	–92.5	–62	–48.5	–38.1	–38.9	–39.8	–50.6	–52.7	–48	N/A	N/A	N/A	N/A	N/A
3	f	101.2	227.11	275.999	276	600	850	1104	1622	2208	2217	N/A	N/A	N/A	N/A
	P	–92.5	–62	–48.5	–38.9	–40.1	–40.9	–41.5	–52.7	–55.2	–48	N/A	N/A	N/A	N/A
4	f	101.2	227.11	275.999	276	400	600	850	1104	1622	2208	2220	N/A	N/A	N/A
	P	–92.5	–62	–48.5	–39.7	–40.4	–41.4	–42.3	–43.2	–54.8	–57.6	–48	N/A	N/A	N/A
5	f	101.2	227.11	275.999	276	400	600	850	1104	1350	1622	2208	2223	N/A	N/A
	P	–92.5	–62	–48.5	–40.5	–41.4	–42.6	–43.8	–44.9	–51.1	–56.8	–60.1	–48.1	N/A	N/A
6	f	101.2	227.11	275.999	276	400	600	850	1104	1350	1622	2208	2226	2500	N/A
	P	–92.5	–62	–48.5	–41.3	–42.4	–43.8	–45.2	–46.5	–52.9	–58.9	–62.5	–48.1	–48.8	N/A
7	f	101.2	227.11	275.999	276	400	600	850	1104	1350	1622	2208	2229	2500	N/A
	P	–92.5	–62	–48.5	–42.1	–43.4	–45	–46.7	–48.2	–54.8	–61	–65	–48.2	–48.8	N/A
8	f	101.2	227.11	275.999	276	400	600	850	1104	1350	1622	2208	2232	2500	N/A
	P	–92.5	–62	–48.5	–42.9	–44.4	–46.2	–48.1	–49.9	–56.7	–63	–67.5	–48.3	–48.8	N/A
9	f	101.2	227.11	275.999	276	400	600	850	1104	1350	1622	2208	2235	2500	N/A
	P	–92.5	–62	–48.5	–43.7	–45.4	–47.4	–49.6	–51.6	–58.5	–65.1	–69.9	–48.3	–48.8	N/A
10	f	101.2	227.11	275.999	276	400	600	850	1104	1350	1622	2208	2239	N/A	N/A
	P	–92.5	–62	–48.5	–44.6	–46.4	–48.7	–51.1	–53.3	–60.5	–67.3	–72.5	–48.1	N/A	N/A
11	f	101.2	227.11	275.999	276	400	600	850	1104	1350	1622	2208	2242	2500	N/A
	P	–92.5	–62	–48.5	–45.5	–47.5	–50.1	–52.8	–55.2	–62.6	–69.6	–75.3	–48.2	–48.8	N/A
12	f	101.2	227.11	275.999	276	400	600	850	1104	1350	1622	2208	2246	N/A	N/A
	P	–92.5	–62	–48.5	–46.4	–48.6	–51.5	–54.4	–57.1	–64.7	–71.9	–78.1	–48.1	N/A	N/A
13	f	101.2	227.11	275.999	276	400	600	850	1104	1350	1622	2198	2208	2248	N/A
	P	–92.5	–62	–48.5	–47.3	–49.7	–52.8	–56	–58.9	–66.8	–74.2	–80.6	–80	–48.1	N/A
14	f	101.2	227.11	275.999	276	400	600	850	1104	1350	1622	2162	2208	2248	N/A
	P	–92.5	–62	–48.5	–48.1	–50.7	–54.1	–57.6	–60.7	–68.8	–76.4	–82.9	–80	–48.1	N/A
15	f	101.2	227.11	274	276	400	600	850	1104	1350	1622	2129	2208	2248	N/A
	P	–92.5	–62	–49	–49	–51.8	–55.4	–59.1	–62.5	–70.7	–78.6	–85.1	–80	–48.1	N/A
16	f	101.2	227.11	271	276	400	600	850	1104	1350	1622	2097	2208	2248	N/A
	P	–92.5	–62	–49.8	–49.8	–52.8	–56.6	–60.6	–64.2	–72.6	–80.7	–87.2	–80	–48.1	N/A
17	f	101.2	227.11	268	276	400	600	850	1104	1350	1622	2067	2208	2248	N/A
	P	–92.5	–62	–50.6	–50.6	–53.8	–57.8	–62	–65.9	–74.5	–82.8	–89.2	–80	–48.1	N/A
18	f	101.2	227.11	265	276	400	600	850	1104	1350	1622	2039	2208	2248	N/A
	P	–92.5	–62	–51.4	–51.4	–54.7	–59	–63.5	–67.5	–76.3	–84.8	–91.1	–80	–48.1	N/A
19	f	101.2	227.11	262	276	400	600	850	1104	1350	1622	1912	2033	2208	2248
	P	–92.5	–62	–52.1	–52.1	–55.7	–60.2	–64.9	–69.1	–78.1	–86.7	–91.5	–91.5	–80	–48.1
20	f	101.2	227.11	259	276	400	600	850	1104	1350	1622	1782	2033	2208	2248
	P	–92.5	–62	–52.9	–52.9	–56.6	–61.3	–66.2	–70.6	–79.8	–88.7	–91.5	–91.5	–80	–48.1
21	f	101.2	227.11	256	276	400	600	850	1104	1350	1622	1673	2033	2208	2248
	P	–92.5	–62	–53.7	–53.6	–57.5	–62.4	–67.5	–72.2	–81.5	–90.5	–91.5	–91.5	–80	–48.1
22	f	101.2	227.11	253.999	276	400	600	850	1104	1350	1594	2033	2208	2248	N/A
	P	–92.5	–62	–54.3	–54.3	–58.3	–63.5	–68.8	–73.6	–83.2	–91.5	–91.5	–80	–48.1	N/A
23	f	101.2	227.11	251	276	400	600	850	1104	1350	1540	2033	2208	2248	N/A
	P	–92.5	–62	–55.1	–55	–59.2	–64.5	–70.1	–75.1	–84.8	–91.5	–91.5	–80	–48.1	N/A

IL		f_1 P_1	f_2 P_2	f_3 P_3	f_4 P_4	f_5 P_5	f_6 P_6	f_7 P_7	f_8 P_8	f_9 P_9	f_{10} P_{10}	f_{11} P_{11}	f_{12} P_{12}	f_{13} P_{13}	f_{14} P_{14}
24	f	101.2	227.11	249	276	400	600	850	1104	1350	1491	2031	2206	2246	N/A
	P	–92.5	–62	–55.7	–55.7	–60	–65.5	–71.3	–76.5	–86.3	–91.5	–91.5	–80	–48.1	N/A
25	f	101.2	227.11	247	276	400	600	850	1104	1350	1447	1911	2086	2126	N/A
	P	–92.5	–62	–56.3	–56.3	–60.8	–66.5	–72.5	–77.8	–87.8	–91.5	–91.5	–80	–47.8	N/A
26	f	101.2	227.11	244	276	400	600	850	1104	1350	1406	1807	1982	2022	2208
	P	–92.5	–62	–57	–57	–61.6	–67.5	–73.6	–79.2	–89.3	–91.5	–91.5	–80	–47.6	–48
27	f	101.2	227.11	242	276	400	600	850	1104	1369	1693	1868	1908	2208	N/A
	P	–92.5	–62	–57.6	–57.6	–62.3	–68.4	–74.7	–80.4	–91.5	–91.5	–80	–47.3	–48	N/A
28	f	101.2	227.11	240	276	400	600	850	1104	1334	1593	1768	1808	2208	N/A
	P	–92.5	–62	–58.2	–58.2	–63.1	–69.3	–75.8	–81.7	–91.5	–91.5	–80	–47	–48	N/A
29	f	101.2	227.11	238	276	400	600	850	1104	1301	1505	1680	1720	2208	N/A
	P	–92.5	–62	–58.8	–58.7	–63.8	–70.2	–76.8	–82.9	–91.5	–91.5	–80	–46.8	–48	N/A
30	f	101.2	227.11	236	276	400	600	850	1104	1270	1433	1608	1648	2208	N/A
	P	–92.5	–62	–59.3	–59.3	–64.5	–71	–77.9	–84	–91.5	–91.5	–80	–46.6	–48	N/A
31	f	101.2	227.11	234	276	400	600	850	1104	1240	1380	1555	1595	1622	2208
	P	–92.5	–62	–59.9	–59.9	–65.2	–71.9	–78.9	–85.2	–91.5	–91.5	–80	–46.1	–46.5	–48
32	f	101.2	227.11	232	276	400	600	850	1104	1205	1322	1497	1538	1622	2208
	P	–92.5	–62	–60.6	–60.6	–66	–73	–80.2	–86.7	–91.5	–91.5	–80	–45.1	–46.5	–48
33	f	101.2	227.11	230	276	400	600	850	1104	1172	1268	1443	1485	1622	2208
	P	–92.5	–62	–61.3	–61.3	–66.9	–74	–81.5	–88.2	–91.5	–91.5	–80	–44.2	–46.5	–48
34	f	101.2	227.11	276	400	600	850	1104	1141	1217	1392	1434	1622	2208	N/A
	P	–92.5	–62	–62	–67.8	–75.1	–82.7	–89.6	–91.5	–91.5	–80	–43.6	–46.5	–48	N/A
35	f	101.2	223	276	400	600	850	1104	1111	1169	1344	1387	1622	2208	N/A
	P	–92.5	–62.7	–62.7	–68.6	–76.2	–84	–91.1	–91.5	–91.5	–80	–42.4	–46.5	–48	N/A
36	f	101.2	219	276	400	600	850	1061	1122	1297	1341	1622	2208	N/A	N/A
	P	–92.5	–63.4	–63.4	–69.5	–77.2	–85.3	–91.5	–91.5	–80	–41.6	–46.5	–48	N/A	N/A
37	f	101.2	215	276	400	600	850	1009	1077	1252	1296	1622	2208	N/A	N/A
	P	–92.5	–64.1	–64.1	–70.4	–78.3	–86.6	–91.5	–91.5	–80	–41	–46.5	–48	N/A	N/A
38	f	101.2	211	276	400	600	850	962	1036	1211	1256	1622	2208	N/A	N/A
	P	–92.5	–64.8	–64.8	–71.2	–79.4	–87.9	–91.5	–91.5	–80	–39.9	–46.5	–48	N/A	N/A
39	f	101.2	207	276	400	600	850	919	996	1171	1217	1622	2208	N/A	N/A
	P	–92.5	–65.5	–65.5	–72.1	–80.5	–89.2	–91.5	–91.5	–80	–39	–46.5	–48	N/A	N/A
40	f	101.2	203	276	400	600	850	880	959	1134	1180	1622	2208	N/A	N/A
	P	–92.5	–66.2	–66.2	–73	–81.5	–90.4	–91.5	–91.5	–80	–38.3	–46.5	–48	N/A	N/A
41	f	101.2	199	276	400	600	843	921	1096	1143	1622	2208	N/A	N/A	N/A
	P	–92.5	–67	–66.9	–73.8	–82.6	–91.5	–91.5	–80	–37.4	–46.5	–48	N/A	N/A	N/A
42	f	101.2	196	276	400	600	803	857	1032	1079	1104	1622	2208	N/A	N/A
	P	–92.5	–67.6	–67.6	–74.7	–83.7	–91.5	–91.5	–80	–36.5	–36.5	–46.5	–48	N/A	N/A
43	f	101.2	192	276	400	600	768	800	975	1021	1104	1622	2208	N/A	N/A
	P	–92.5	–68.4	–68.4	–75.6	–84.8	–91.5	–91.5	–80	–36.7	–36.5	–46.5	–48	N/A	N/A
44	f	101.2	188	276	400	600	735	749	924	970	1104	1622	2208	N/A	N/A
	P	–92.5	–69.1	–69.1	–76.4	–85.8	–91.5	–91.5	–80	–36.5	–36.5	–46.5	–48	N/A	N/A
45	f	101.2	185	276	400	600	703	877	922	1104	1622	2208	N/A	N/A	N/A
	P	–92.5	–69.8	–69.8	–77.3	–86.9	–91.4	–80	–36.5	–36.5	–46.5	–48	N/A	N/A	N/A
> 45	f	101.2	185	276	400	600	703	877	922	1104	1622	2208	N/A	N/A	N/A
	P	–92.5	–91.5	–91.5	–91.5	–91.5	–91.4	–80	–36.5	–36.5	–46.5	–48	N/A	N/A	N/A

NOTE 1: The label "N/A" denotes that a breakpoint is not used.

NOTE 2: The breakpoints for IL > 45 dB may be too restrictive for VDSL2, refinements are for further study.

In the special case that VDSL2 is deployed from the local exchange, the IL-value is zero. Figure 5 illustrates the limits of the spectral powers (measured in 10 kHz and in 100 kHz) as function of the frequency, according to the specifications in table 9 and table 10.

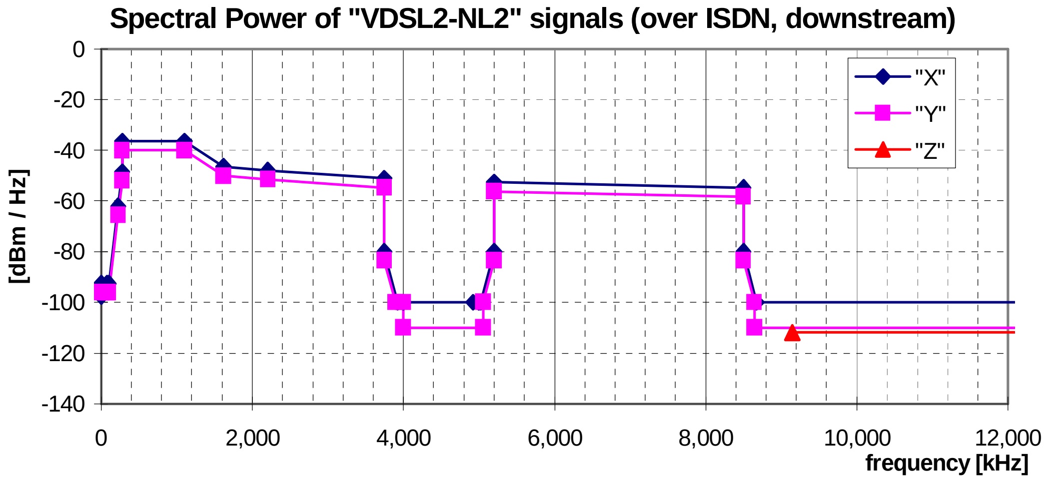

Figure 5: Spectral Power for "VDSL2-NL2" (over ISDN) signals, as specified in table 9 and table 10 for IL=0 dB.

When VDSL2 is deployed from the cabinet, shaping of the above spectral powers between 276 kHz and 2500 kHz can be significant. Figure 6 illustrates the limits of these spectral powers (measured in 10 kHz and in 100 kHz) for various IL-values. (for IL =10 dB, IL=20 dB and IL=40 dB).

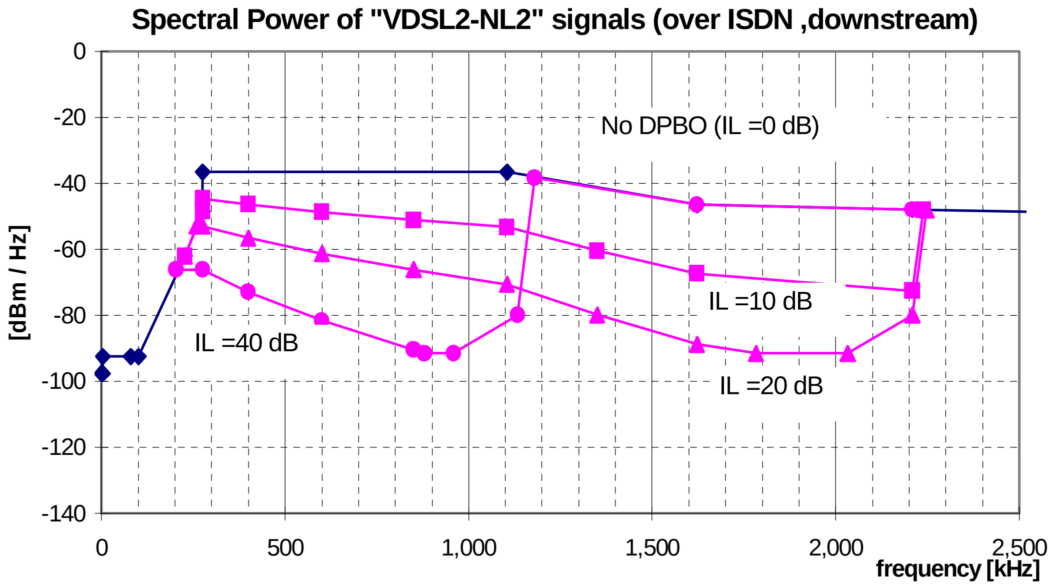

Figure 6: Spectral Power for "VDSL2-NL2" (over ISDN) signals, as specified in table 9 and table 10 in the frequency region where Downstream PSD Shaping has been applied.

2.2.5. Narrow-band signal power (upstream only)

To be compliant with this signal category, the Narrow-Band Signal Power (NBSP) into a resistive load impedance R, shall not exceed the limits given in table 11, at any point in the frequency range 100 Hz to 30 MHz. This table specifies the break points of these limits. Limits for intermediate frequencies can be found by drawing a straight line between the break points on a logarithmic (Hz) - linear (dB) scale below 3575 KHz and linear (Hz) - linear (dB) scale above 3575 KHz.

Figure 7 illustrates the NBSP in a bandwidth-normalized way.

The NBSP is the average power ***P*** of a sending signal into a load resistance ***R***, within a *power* bandwidth ***B***. The measurement method of the NBSP is described in clause 13.2

NOTE 1: The NBSP specification in table 11 is reconstructed from the commonly used PSD specifications in [1] (similar to figure 7), and used here since it is much wider applicable. This enables a unified specification method. PSD specifications are adequate when signals are purely random in nature, but cannot cover harmonic components in a signal (would cause infinite high "PSD" levels at these harmonic frequencies). NBSP specifications cover both signal types.

NOTE 2: The NBSP specification of this signal category has been split into two overlapping limits: "X" and "Y". Both upper limits shall hold simultaneously. The 10 kHz bandwidth values represent the "maximum PSD values" from [1], and includes the pass band ripple. The 100 kHz bandwidth values represent the "average PSD values" in the passband to smooth out the spectral ripple of 3,5 dB. The 1 MHz bandwidth specification is equivalent to the sliding window specification being common for ADSL (see [4] and [3]).

Reference: ITU-T Recommendation G.993.2 [1], clause B2.4 reconstructed from PSD requirements.

Table 11: Break points of the narrow-band power limits

Centre frequency f	Impedance R	Signal Level P	Power bandwidth B	Spectral Power P/B	
0,1 kHz	600 Ω	–77,5 dBm	100 Hz	–97,5 dBm/Hz	“X”
4 kHz	600 Ω	–77,5 dBm	100 Hz	–97,5 dBm/Hz	
4 kHz	100 Ω	–52,5 dBm	10 kHz	–92,5 dBm/Hz	
50 kHz	100 Ω	–50 dBm	10 kHz	–90 dBm/Hz	
80 kHz	100 Ω	–41,8 dBm	10 kHz	–81,8 dBm/Hz	
120 kHz	100 Ω	5,5 dBm	10 kHz	–34,5 dBm/Hz	
276 kHz	100 Ω	5,5 dBm	10 kHz	–34,5 dBm/Hz	
508,8 kHz	100 Ω	–58 dBm	10 kHz	–98 dBm/Hz	
686 kHz	100 Ω	–60 dBm	10 kHz	–100 dBm/Hz	
783 kHz	100 Ω	–60 dBm	10 kHz	–100 dBm/Hz	
2825 kHz	100 Ω	–60 dBm	10 kHz	–100 dBm/Hz	
3000 kHz	100 Ω	–60 dBm	10 kHz	–100 dBm/Hz	
3000 kHz	100 Ω	–60 dBm	10 kHz	–100 dBm/Hz	
3575 kHz	100 Ω	–60 dBm	10 kHz	–100 dBm/Hz	
3750 kHz	100 Ω	–40 dBm	10 kHz	–80 dBm/Hz	
3750 kHz	100 Ω	–11,2 dBm	10 kHz	–51,2 dBm/Hz	
5200 kHz	100 Ω	–12,7 dBm	10 kHz	–52,7 dBm/Hz	
5200 kHz	100 Ω	–40 dBm	10 kHz	–80 dBm/Hz	
5375 kHz	100 Ω	–60 dBm	10 kHz	–100 dBm/Hz	
6875 kHz	100 Ω	–60 dBm	10 kHz	–100 dBm/Hz	
7050 kHz	100 Ω	–60 dBm	10 kHz	–100 dBm/Hz	
7050 kHz	100 Ω	–60 dBm	10 kHz	–100 dBm/Hz	
8325 kHz	100 Ω	–60 dBm	10 kHz	–100 dBm/Hz	
8500 kHz	100 Ω	–40 dBm	10 kHz	–80 dBm/Hz	
8500 kHz	100 Ω	–14,8 dBm	10 kHz	–54,8 dBm/Hz	
10000 kHz	100 Ω	–15,5 dBm	10 kHz	–55,5 dBm/Hz	
12000 kHz	100 Ω	–16,5 dBm	10 kHz	–56,5 dBm/Hz	
12000 kHz	100 Ω	–40 dBm	10 kHz	–80 dBm/Hz	
12175 kHz	100 Ω	–60 dBm	10 kHz	–100 dBm/Hz	
14350 kHz	100 Ω	–60 dBm	10 kHz	–100 dBm/Hz	
14351 kHz	100 Ω	–60 dBm	10 kHz	–100 dBm/Hz	
14526 kHz	100 Ω	–60 dBm	10 kHz	–100 dBm/Hz	
30000 kHz	100 Ω	–60 dBm	10 kHz	–100 dBm/Hz	

Centre frequency f	Impedance R	Signal Level P	Power bandwidth B	Spectral Power P/B	
50 kHz	100 Ω	–43,5 dBm	100 kHz	–93.5 dBm/Hz	“Y”
80 kHz	100 Ω	–35,3 dBm	100 kHz	–85.3 dBm/Hz	
120 kHz	100 Ω	+12 dBm	100 kHz	–38 dBm/Hz	
276 kHz	100 Ω	+12 dBm	100 kHz	–38 dBm/Hz	
508,8 kHz	100 Ω	–50 dBm	100 kHz	–100 dBm/Hz	
686 kHz	100 Ω	–50 dBm	100 kHz	–100 dBm/Hz	
783 kHz	100 Ω	–50 dBm	100 kHz	–100 dBm/Hz	
2825 kHz	100 Ω	–50 dBm	100 kHz	–100 dBm/Hz	
2999,999 kHz	100 Ω	–50 dBm	100 kHz	–100 dBm/Hz	
3000 kHz	100 Ω	–50 dBm	100 kHz	–100 dBm/Hz	
3575 kHz	100 Ω	–50 dBm	100 kHz	–100 dBm/Hz	
3749,999 kHz	100 Ω	–33,5 dBm	100 kHz	–83,5 dBm/Hz	
3750 kHz	100 Ω	–5,7 dBm	100 kHz	–54,7 dBm/Hz	
5199,999 kHz	100 Ω	–6,2 dBm	100 kHz	–56,2 dBm/Hz	
5200 kHz	100 Ω	–33,5 dBm	100 kHz	–83,5 dBm/Hz	
5375 kHz	100 Ω	–60 dBm	100 kHz	–110 dBm/Hz	
6875 kHz	100 Ω	–60 dBm	100 kHz	–110 dBm/Hz	
7049,999 kHz	100 Ω	–60 dBm	100 kHz	–110 dBm/Hz	
7050 kHz	100 Ω	–60 dBm	100 kHz	–110 dBm/Hz	
8325 kHz	100 Ω	–60 dBm	100 kHz	–110 dBm/Hz	
8499,999 kHz	100 Ω	–33,5 dBm	100 kHz	–83,5 dBm/Hz	
8500 kHz	100 Ω	–8,3 dBm	100 kHz	–58,3 dBm/Hz	
10000 kHz	100 Ω	–9 dBm	100 kHz	–59 dBm/Hz	
11999,999 kHz	100 Ω	–10 dBm	100 kHz	–60 dBm/Hz	
12000 kHz	100 Ω	–33,5 dBm	100 kHz	–83,5 dBm/Hz	
12175 kHz	100 Ω	–60 dBm	100 kHz	–110 dBm/Hz	
14350 kHz	100 Ω	–60 dBm	100 kHz	–110 dBm/Hz	
14351 kHz	100 Ω	–60 dBm	100 kHz	–110 dBm/Hz	
14526 kHz	100 Ω	–60 dBm	100 kHz	–110 dBm/Hz	
30000 kHz	100 Ω	–60 dBm	100 kHz	–110 dBm/Hz	
12675 kHz	100 Ω	–52 dBm	1 MHz	–112 dBm/Hz	“Z”
14350 kHz	100 Ω	–52 dBm	1 MHz	–112 dBm/Hz	
14351 kHz	100 Ω	–52 dBm	1 MHz	–112 dBm/Hz	
14526 kHz	100 Ω	–52 dBm	1 MHz	–112 dBm/Hz	
30000 kHz	100 Ω	–52 dBm	1 MHz	–112 dBm/Hz	

NOTE 1: The PSD values between breakpoints shall be obtained by interpolation between adjacent breakpoints as follows:

- below *3575* kHz: on a dB / $\log_{10}(f)$ basis and
- above *3575* kHz: on a dB / f basis

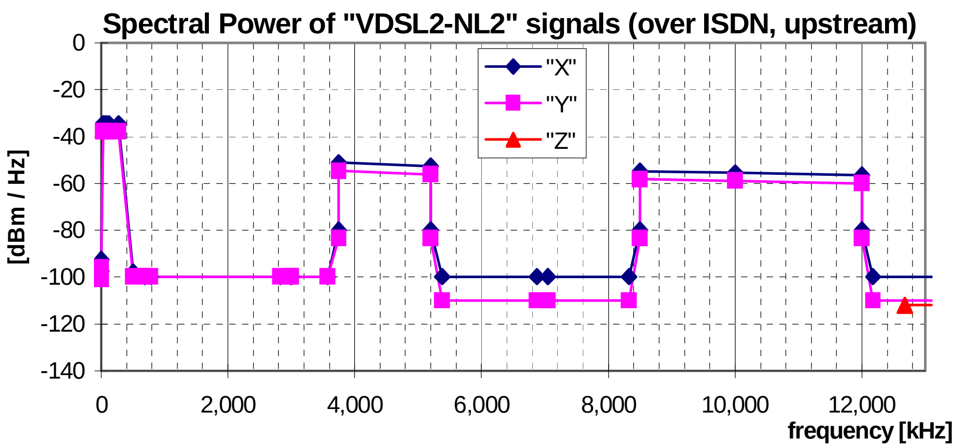

Figure 7: Spectral Power, for “VDSL2-NL2” (over ISDN) signals, as specified in table 11.

2.2.6. Unbalance about earth (upstream and downstream)

To be compliant with this signal category, the balance of the signal that may flow through the LT-port or NT-port shall exceed minimum requirements, under the condition that the local loop wiring and its termination is well balanced. This can be verified by a Longitudinal Output Voltage (LOV) and a Longitudinal Conversion Loss (LCL) measurement at the source of that signal, as specified in clause 13.3.2 and 13.3.3. The minimum LOV and LCL requirements hold for what can be observed at the ports of the Local Loop Wiring, when the Local Loop Wiring is replaced by an artificial impedance network described in,clause 13.3.2 and 13.3.3.

The differential termination impedance for LOV and LCL measurements shall be chosen equally to the design impedance R_T = 100 Ω of the Signal Source under test.

The observed LOV shall have an rms voltage of below the value specified in table 12, measured in a *power* bandwidth B, centred over any frequency in the range from f_{min} to f_{max}, and averaged in any one second period. Compliance with this limitation is required with a longitudinal terminating impedance having value $Z_L(\omega) = R_L + 1 / (j\omega \times C_L)$ for all frequencies between f_{min} to f_{max}. Clause 13.3.2 defines an example measurement method for longitudinal output voltage.

The observed LCL shall be higher than the lower limits given in figure 8. The LCL values of the associated break frequencies of this figure are given in table 13. Clause 13.3.3 in defines an example measurement method for longitudinal conversion loss. To be compliant with this signal category, this requirement shall be met for both the switched-on and switched-off mode of the signal source.

Reference: TS 101 270-1, clauses 8.3.3 and E.3.2 [2].

Table 12: Values for the LOV limits

	LOV	B	f_{min}	f_{max}	R_L	C_L
downstream	–46 dBV	10 kHz	5,1 kHz	1 825 kHz	100 Ω	150 nF
upstream	–46 dBV	10 kHz	5,1 kHz	210 kHz	100 Ω	150 nF

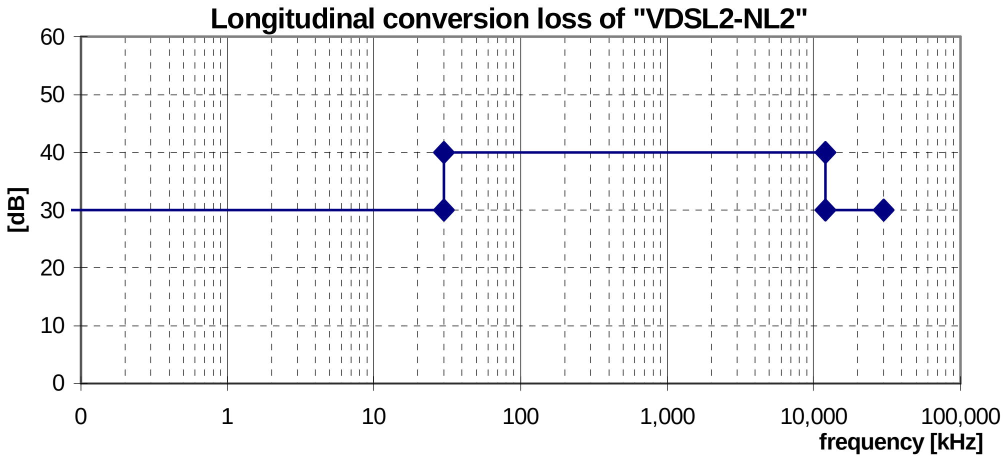

Figure 8: Minimum longitudinal conversion loss

Table 13: Frequencies and LCL values of the breakpoints of the LCL mask in figure 8

Frequency	LCL
< 30 kHz	30 dB
30 kHz	40 dB
12 MHz	40 dB
12 MHz	30 dB
30 MHz	30 dB